3

Evaluating the Biological Effects of Combined Sewer Overflows in Ohio

A demonstration project was initiated to examine the utility of biological assessment in general and RBPs specifically for evaluating impairment due to CSOs. The study objectives were to:

- Evaluate the impact of CSOs on the benthic macroinvertebrate assemblage at test sites by identifying changes in taxonomic structure, composition, and trophic function;
- Determine the usefulness of RBPs in detecting those effects; and
- Evaluate the agreement of RBPs with historical assessments produced by Ohio EPA.

3.1 Site Selection and Location Description

Three sites that have a history of CSO study were selected for this investigation: the Scioto River at Columbus, the Sandusky River at Bucyrus, and the Little Cuyahoga River at Akron (Figure 3-1). These sites were selected because they represent different regions of the state and are therefore likely to exhibit different biological expectations, and because historical biological data are available. The sites were located with the intention of having one station upstream of any CSO effects, one downstream of all CSO inputs, another far enough downstream to perhaps be in a recovery zone, and a fourth to represent regional reference conditions for each stream (Table 3-1). However, the regional reference site for the Little Cuyahoga River could not be sampled due to flooding; that assessment was based on an upstream condition.

3.2 Results

3.2.1 Taxonomy and Metrics

Taxonomic results and counting exceptions are presented in Appendix A; the results of the metric calculations are shown within the section for each CSO site.

Separate bioassessment scoring criteria were developed for each river under study based on metric values acquired. The scoring criteria are based on equal quadrisections of the value range from the lowest possible value for a metric (usually zero) to the maximum observed, usually observed at the regional reference. The scoring criteria used for each of the three sites are summarized by metric in Table 3-2.

3.2.2 The Scioto River at Columbus, Ohio

The Scioto River is a major tributary of the southern Ohio River (Figure 3-1). It originates in northwestern Ohio in Hardin County in what is known as Scioto Marsh (Ohio EPA 1979). It flows east 60 miles and then south 175 miles to its confluence with the Ohio River at Portsmouth. The Scioto River drainage area, approximately 6,500 square miles, displays a branching stream pattern with tributaries flowing through gorges north of Columbus (Ohio EPA 1986). Flows in the river channel are regulated by two major impoundments and three low-head dams in the central Ohio stretch of the river. Channelization with concrete reinforcement and levees occurs in some of the municipal areas; these channel modifications continue to just upstream of the Jackson Pike Waste Water Treatment Plant (WWTP) (River Mile [RM] 127.1). CSO outfalls are concentrated between RM 132.3 and 129.8 upstream of Jackson Pike. South of Jackson Pike, evidence of impoundment and other channel modifications disappears. The channel is typical of a lotic environment with good sinuosity and riffle-pool sequences. The river is situated over a buried valley filled with glacial outwash material (sand and coarse gravel). Therefore, the substrate ranges from limestone bedrock and silt/muck north of Columbus to coarse sand and gravel/cobble south of Columbus. Flooding in this area has been known to cover extensive areas of the floodplain. This study covers the area of the Scioto from 5 miles upstream of the confluence with the Olentangy River (RM 132.3) to approximately 20 miles south of Columbus at Circleville (RM 100.0) (Figure 3-2). At the northernmost sampling station the drainage area of the Scioto River is approximately 980 square miles; at the southernmost site it is 3,849 square miles.

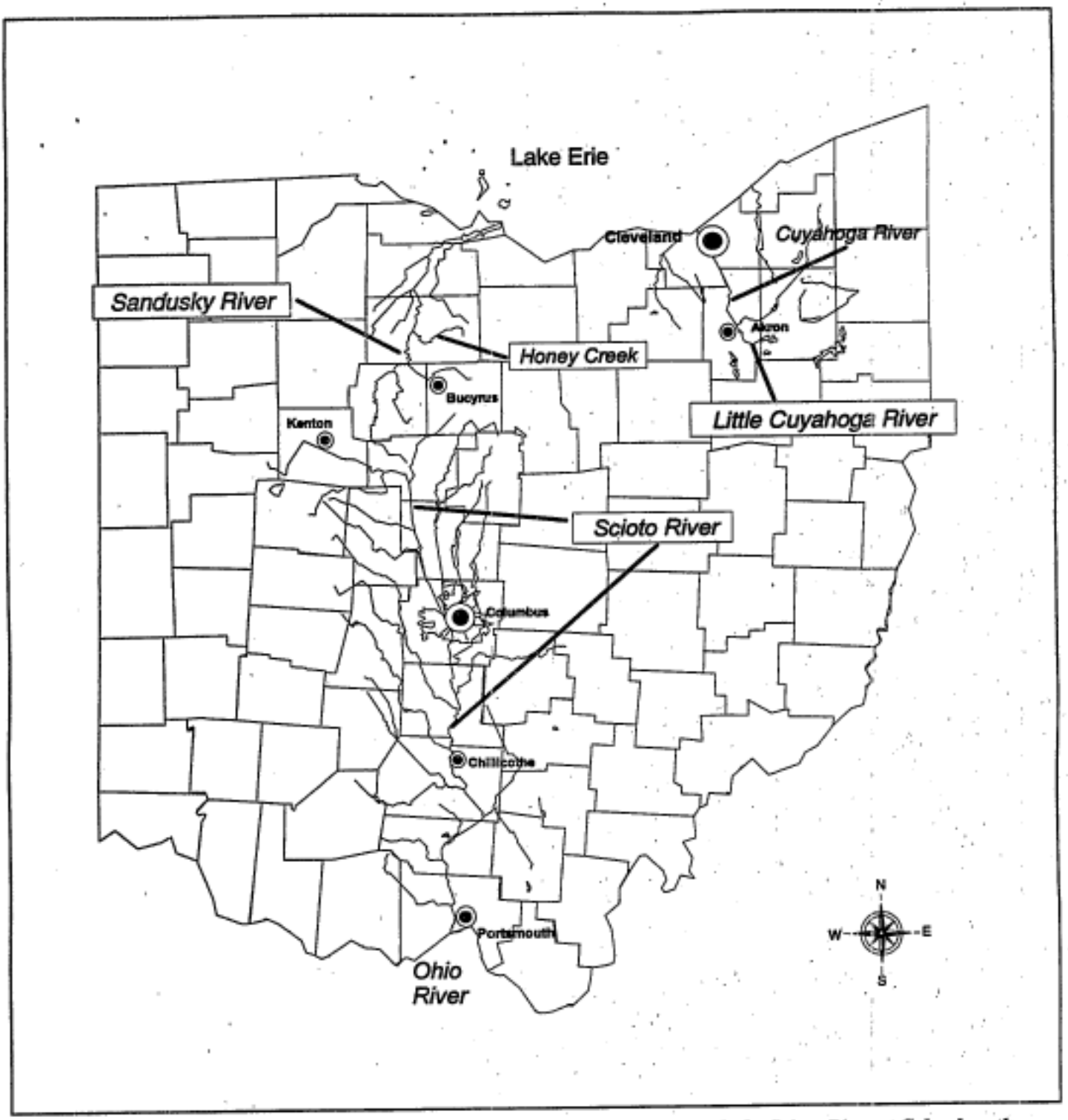

Figure 3-1. State of Ohio; three river systems within which the CSO study occurred: the Scioto River at Columbus, the Sandusky River at Bucyrus, and the Little Cuyahoga River at Akron. Honey Creek serves as a regional reference stream for the Sandusky River.

Table 3-1 Biological sampling stations in Ohio. Sampled 8-9, 24 September 1992.

STATION LABEL	STATION TYPE	RIVER MILE	LOCATION OF SAMPLING STATION
S1	Upstream Reference	136.4 Scioto	200 meters downstream from the Fifth Avenue bridge in western Columbus
S2	CSO Impact	129.5 Scioto	200 meters downstream of the Greenlawn Avenue bridge in Columbus about 2 miles upstream of the Frank Road station (S3)
S3	CSO Impact	127.7 Scioto	50 meters downstream of Frank Road bridge (Hwy. 104) in Columbus
S4	Regional Reference	99.9 Scioto	200 meters upstream of Hwy. 22 bridge (20 miles south of Columbus at Circleville)
SA1	Upstream Reference	115.0 Sandusky	150 meters upstream of Hwy. 30 bridge at the Fish Hatchery in Bucyrus
SA2	CSO Impact	111.5 Sandusky	700 meters upstream of Bucyrus WWTP at the downstream edge of Aumiller Park (RM 114.4)
SA3	CSO Impact	111.1 Sandusky	50 meters upstream of Bucyrus WWTP
SA4	Regional Reference	12.5 Honey Creek	50 meters upstream of Hwy. 100 bridge (20 miles north of Bucyrus on Hwy. 100 at Melmore)
CR1	Upstream Reference	11.3 Little Cuyahoga	500 meters upstream of Gilchrist Road bridge in Mogadore
CR2	Upstream[a]	7.1 Little Cuyahoga	Immediately downstream of Massillon Rd. bridge in Akron
CR3	CSO Impact	0.3 Little Cuyahoga	At the Police Firing Range off Cuyahoga Street in Akron

[a]In selecting this sampling location, it was originally thought that it could be considered a CSO receiving station. According to Ohio EPA (J. DeShon, pers. comm.), the outfall(s) upstream of Massillon Road had been eliminated some time prior to our sampling; thus, impacts from CSOs were expected to be evident only at CR3.

Table 3-2 Scoring criteria developed for the benthic macroinvertebrate assemblage on each Ohio study river using USEPA's rapid bioassessment protocols. For a description of the development of scoring criteria, see Section 2.3.1.

ASSESSMENT SCORES	SCORING CRITERIA											
	0	2	4	6	0	2	4	6	0	2	4	6
METRIC	*SCIOTO RIVER*				*SANDUSKY RIVER*				*LITTLE CUYAHOGA RIVER*			
1. Taxa richness	0-5	6-10	11-15	≥16	0-6	7-13	14-20	≥ 21	0-4	5-8	9-13	≥14
2. HBI	≥5.3	5.2-3.9	3.8-2.5	≤2.4	≥5.1	5.0-3.7	3.6-2.3	≤2.2	≥6.3	6.2-4.6	4.5-2.9	≤2.8
3. Sc/(Sc+Fc) x 100	0-7.3	7.4-14.7	14.8-22.1	≥22.2	0-19.3	19.4-38.7	38.8-58.1	≥58.2	0-15	16-30	31-45	≥46
4. EPT/(EPT+Chir) x 100	0-25	26-50	51-75	76-100	0-25	26-50	51-75	76-100	0-25	26-50	51-75	76-100
5. % Contribution Dominant Taxon	100-76	75-51	50-26	≤25	100-76	75-51	50-26	≤25	100-76	75-51	50-26	≤25
6. EPT Index	0-3	4-6	7-9	≥10	0-3	4-6	7-9	≥10	0-3	4-6	7-9	≥10
7. Shredders/Tot x 100	0-25	26-50	51-75	76-100	0-25	26-50	51-75	76-100	0-25	26-50	51-75	76-100
8. H/T x 100	100-76	75-51	50-26	≤25	100-76	75-51	50-26	≤25	100-76	75-51	50-26	≤25
9. Pinkham-Pearson	0-1.8	1.9-3.7	3.8-5.6	≥5.7	0-1.6	1.7-3.3	3.4-5	≥5.1	0-1.2	1.3-2.5	2.6-3.8	≥3.9
10. QSI-Tax	0-25	26-50	51-75	76-100	0-25	26-50	51-75	76-100	0-25	26-50	51-75	76-100
11. DIC-5	≤1	2	3	≥4	≤1	2	3	≥4	≤1	2	3	≥4
12. QSI-FFG	0-25	26-50	51-75	76-100	0-25	26-50	51-75	76-100	0-25	26-50	51-75	76-100

3.2.2.1 *Historical Information*

The Scioto River mainstem downstream from Columbus has been monitored frequently over a distance of approximately 40 miles (Ohio EPA 1992) from 1974 to the present. The most current biological data from Ohio EPA are from macroinvertebrate surveys conducted in 1988 and 1991 and fish surveys conducted from 1985 to 1991. The 1988 macroinvertebrate results showed the most severe impacts in the CSO-impacted area (RM 132.3 to 129.8) of the Scioto River study area (Ohio EPA 1992) (Figure 3-3). Invertebrate community index (ICI) values were in the "poor" range and reflected the impact of CSO inputs combined with extremely low river flows due to withdrawals for drinking water and drought. The ICI is Ohio EPA's multiple metric approach for assessing the biological integrity of streams and rivers, and is based on benthic macroinvertebrate samples taken from artificial substrates (Ohio EPA 1987b). Ohio EPA believes that the CSO impacts, at least in part, extended downstream for a distance of 15 to 20 miles. In 1991, another low flow year, the ICI improved somewhat but remained in the lower "fair" range. The combined effects of upstream water withdrawals and drought, old channel modifications, urban runoff, and the input of organic matter and nutrients from CSOs account for the degradation.

The three most upstream sampling sites surveyed in the present study (1992) were also sampled in 1991. These stations were RM 136.3 (136.4 in the present study), RM 129.0 (129.5 in the present study), and RM 127.8 (127.7 in the present study). The farthest downstream station at RM 100 (99.9 in the present study) was sampled in 1989 and 1992. The ICI rated the upstream station (RM 136.3) and farthest downstream station (RM 100) as very good and exceptional, respectively, for macroinvertebrate assemblage condition. RM 129.0 was considered fair in 1991, and RM 127.8 was considered poor; both are in the downstream end of the area of CSO inputs.

3.2.2.2 *Sampling Station Descriptions and Habitat Quality Assessments*

The four sampling stations on the Scioto selected for this study are described in Figure 3-2 and Table 3-1; habitat assessment rating scores, along with measurements of dissolved oxygen, temperature, and conductivity, are presented in Table 3-3.

Scioto River below the Fifth Avenue bridge - Station S1 (upstream reference). Station S1 is a site-specific reference used by Ohio EPA for the Scioto. The river receives no CSO input at or above this location. This station has a large riffle area stretching across the channel; the substrate is composed primarily of gravel and cobble along with some small boulders. Channel stability here appears to be good from observations of bank form and the riparian vegetation. There was an abundance of leaf litter along with some green algae in the kick net samples. The habitat assessment rating score was 145 (Table 3-3).

Scioto River at Greenlawn Avenue - Station S2 (CSO impact). The gravel bars at this station did not support the colonization by grasses, and there was also a broader floodplain that lacked any undergrowth. The habitat score at this station was 131.

Scioto River at Frank Road (Hwy. 104) - Station S3 (CSO impact). This station seemed to have considerable stability in features of channel morphology such as banks and riparian vegetation. There were also relatively low levels of siltation and embeddedness and abundant growths of filamentous green algae growing on rocks. Several gravel bars had developed here in mid- and off-center sections of the channel and had become vegetated by grasses. At this station there was a strong sewage odor during sampling. All CSO input from the city of Columbus is present in the flow by this level (RM 127.7) in the river. This station received a habitat assessment score of 136.

Scioto River at Circleville - Station S4 (regional reference). This sampling station serves as the regional reference site for Ohio EPA. The river here exhibits active bank erosion, formation of large gravel bars, perhaps reflecting increased bedload, and relatively heavy sedimentation. There was also indication of recent out-of-bank flows on one side of the channel floodplain. Habitat rated 117 points at this station. Although the habitat score at station S4 might appear low, it is likely a "natural" artifact of the large river; i.e., the drainage area at this site is 3,200 square miles compared to 1,600 at station S2 and ~1,000 square miles at S1. This river size exceeds the usual applications of the habitat assessment approach used in this study; therefore some of the physical attributes of S4 might be unfairly penalized. Ohio EPA found that ICI metric scores are "lower" at higher drainage areas. Therefore, the habitat quality might be "natural" and comparisons between S1 and S4 might be inappropriate.The quality of the overall habitat structure was best at Station S1 (the upstream site-specific reference) and relatively similar at Stations S2 and S3 (the middle stations). The worst rated condition was observed at Station S4 (Table 3-2), which is considered to be an ecoregional reference station by Ohio EPA. However, the relative magnitude of similarity (i.e., percent comparability) in habitat quality was 80 percent between S1 and S4,which is not a significant difference. Individual components of the physical habitat structure at Station S4 that were rated as suboptimal or marginal were related to erosion and sedimentation (producing embeddedness and siltation of the substrate) and to alteration in channel morphology and bank structure. These problems in habitat structure are most likely a result of the agricultural land use

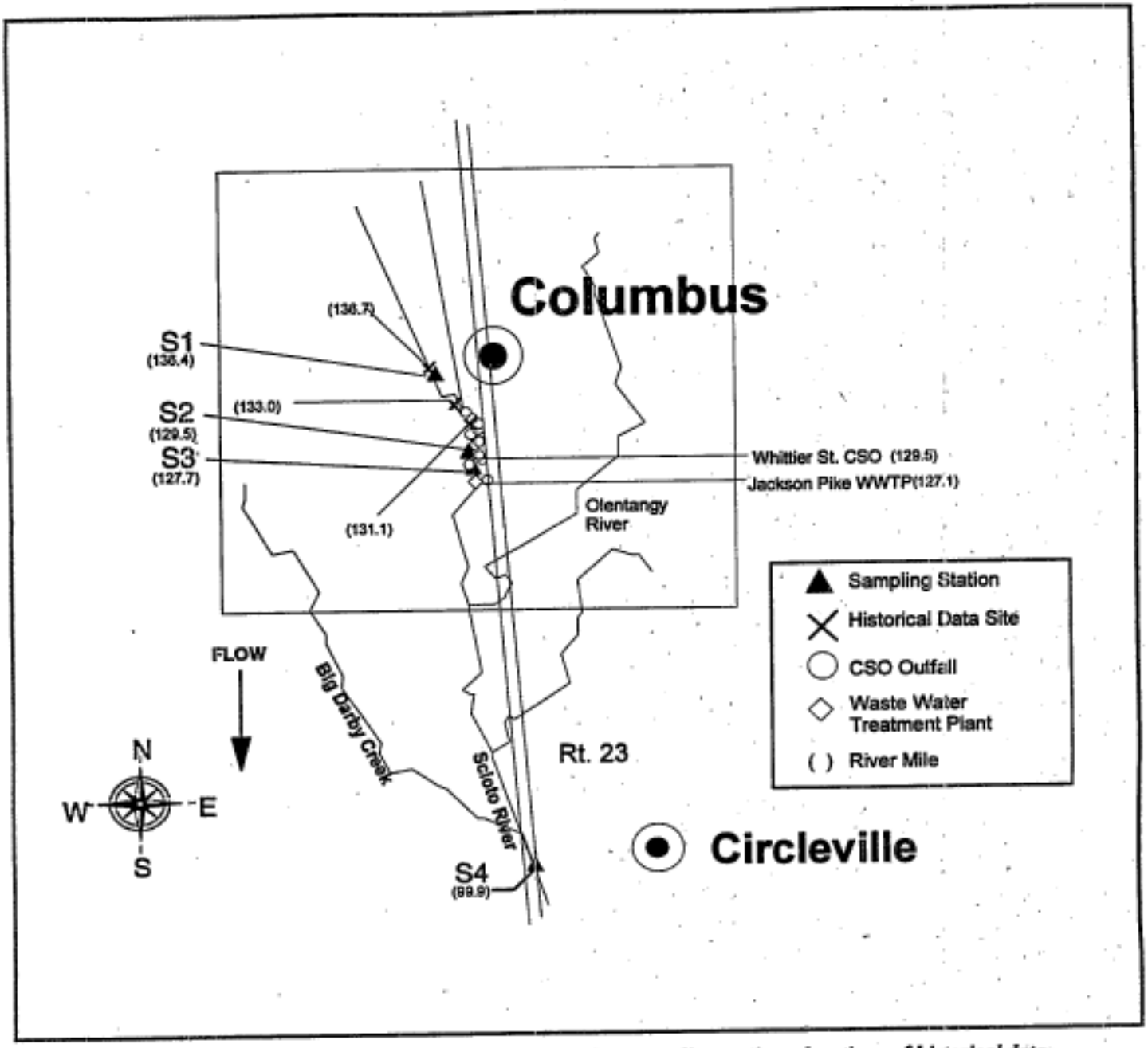

Figure 3-2. Cities of Columbus and Circleville, Ohio; Scioto River sampling stations, locations of historical data collection, CSO outfalls, WWTP, and river mile designations (approximate scale 1 inch = 8.2 miles).

patterns in this area of the Scioto River, located south of Circleville. It is also an area characterized by glacial outwash (C. Yoder, Ohio EPA, January 1993, pers. comm.), a geological condition that contributes to the "degraded" appearance of many large river channels. Stations S2 and S3 are apparently subjected to substantial bedload movement along with dense growths of filamentous algae. Gravel bars were present at Station S3, but were vegetated with grasses, indicating that increases in flow were not frequent enough to flood or destabilize the bars. However, the broader floodplain at Station S2 was not vegetated, which indicated frequent flooding.

In spite of the sedimentation and bedload at the middle stations, habitat should not be limiting to development of the biological community. Differences in biological condition among Stations S1, S2, and S3 may, therefore, be assessed in the context of differences in water quality. Habitat quality might be limiting at Station S4 compared to the site-specific reference. However, Station S4 is consid-

Table 3-3 Habitat assessments and physicochemical measurements of the Scioto River taken on 8 September 1992. For a description of the stations, see Table 3-2 and Section 3.2.2.2.

HABITAT PARAMETERS		SCORES			
		SCIOTO RIVER SAMPLING STATIONS			
		S1	S2	S3	S4
Primary					
Substrate Instream Cover Flow Canopy (0-20)	Bottom Substrate/Instream Cover	18	16	15	17
	Embeddedness	15	14	16	11
	Flow or Velocity/Depth	18	16	16	16
	Canopy Cover (Shading)	10	10	14	8
Secondary					
Channel-Morphology (0-15)	Channel Alteration	13	11	13	9
	Bottom Scouring and Deposition	13	12	11	9
	Pool/Riffle, Run/Bend Ratio	14	11	8	8
	Lower Bank Channel Capacity	11	8	10	8
Tertiary					
Riparian and Bank Structure (0-10)	Bank Stability	9	8	9	6
	Bank Vegetative Stability (Grazing)	8	8	8	7
	Streamside Cover	8	8	8	8
	Riparian Vegetative Zone Width	8	9	8	10
TOTAL SCORE		145	131	136	117
Physicochemical Parameters	Dissolved Oxygen (mg/L) Temperature (C) Conductivity (μMhs)	6.7 23.5 600	8.9 24.9 590	8.9 24.8 600	8.4 23 750

ered to be an appropriate ecoregional reference by Ohio EPA; therefore, the biological condition is expected to be of a reasonably high quality.

3.2.2.3 Biological Assessments

Even though habitat quality was rated lower at the ecoregional reference station at Circleville (S4) due to the river size and the habitat parameters used (Figure 3-4), biological metrics indicated good conditions (Table 3-4). The upstream station (S1) scored only 79 percent of the ecoregional reference, which indicated that the benthic assemblage was slightly impaired before exposure to the CSO discharge. There is an increased abundance of midges at the two middle stations (S2 and S3), resulting in low values of the EPT/Chironomidae ratio (metric 4), a result often seen in stressed situations. Also, lower calculated values of the scraper/filterer collector ratio (metric 3), seen in these same two stations, indicate increased suspended organic particulates in the flow, perhaps resulting from organic enrichment.

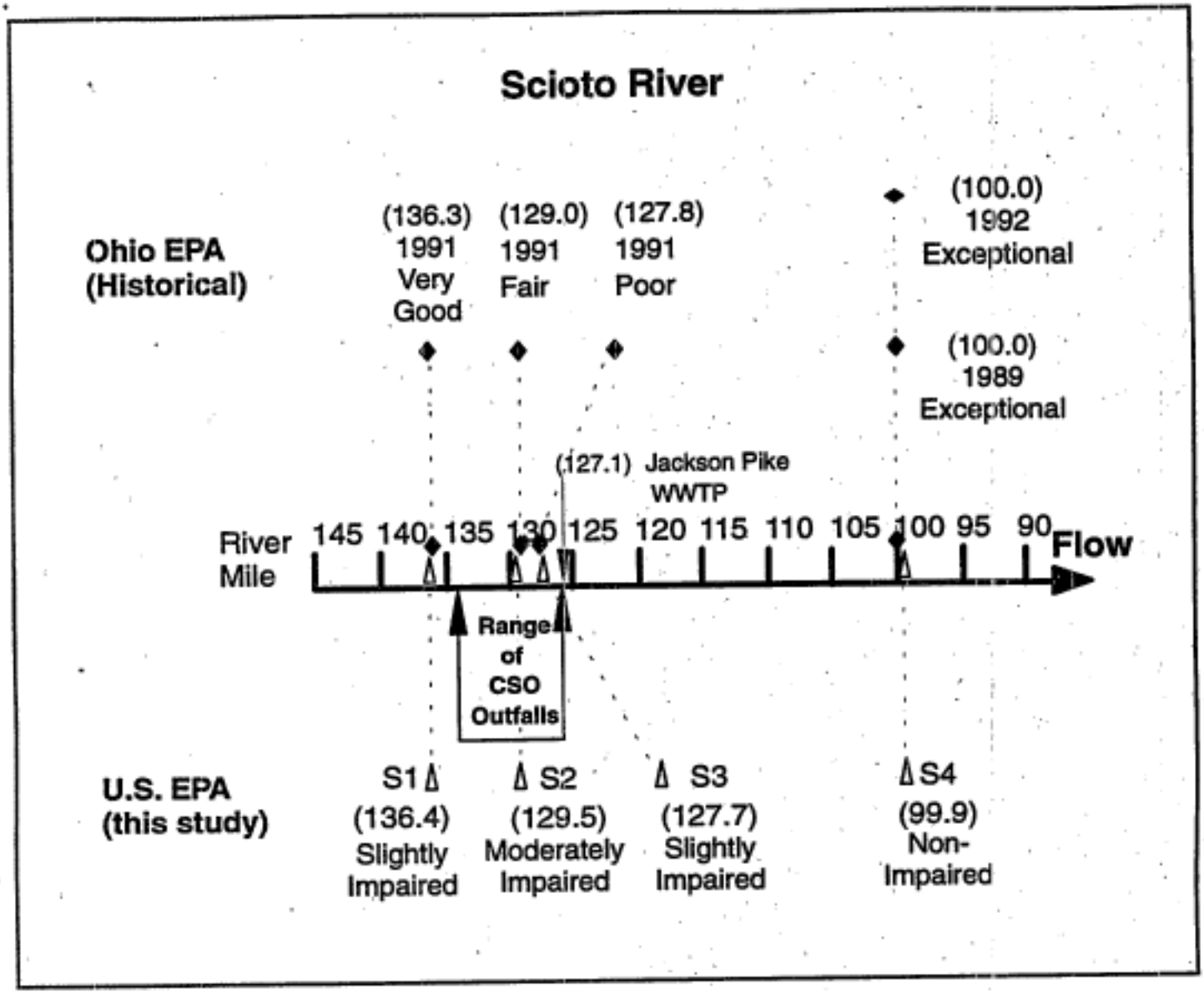

Figure 3-3. Linear comparison with Ohio EPA assessments on the Scioto River.

Station S2, located approximately 4.5 miles downstream of initial CSO outfalls and exactly at the location of the Whittier Street CSO outfall (RM 129.5), received a bioassessment score 50 percent of the reference, indicating moderate impairment. Downstream 2 miles, Station S3 had a bioassess-ment rating that indicated slight impairment (69 percent of reference) and some recovery from the conditions at S2.

3.2.2.4 Comparison to Historical Assessments

The Scioto River has the most extensive history of biological monitoring and assessment of the three CSO sites under investigation in this project (Ohio EPA 1986). The results from Ohio EPA seem to be comparable to those of the present study in which Stations S1 (RM 136.4) and S4 (RM 99.9) were found to be of the best biological quality (Figure 3-3). Stations S2 (RM 129.5) and S3 (RM 127.7) were found to be moderately and slightly impaired. Ohio EPA found its two nearest stations, RM 129.0 and 127.8, to be fair and poor, respectively. The largest discrepancy in the results between the present study and the 1991 Ohio EPA study was between the farthest downstream station within the zone of CSO outfalls, RMs 127.8 (Ohio EPA) and 127.7 (present). The former was found in 1991 to be in "poor" condition by the ICI and in "slightly impaired" condition by the RBPs. This difference may be a sign of improvement in water quality during the time between the two sampling events. However, an alternative explanation is that the differences in the macroinvertebrate communities were due to the differences in flow between 1991 (a very dry year) and 1992 (a very wet year). Ohio EPA data (Ohio EPA 1992) suggest that more severe degradation in areas of

CSO releases are experienced in the dry years. This may be due to the material deposited by CSOs in previous years which may exert strong effects on biologoical factors such as 0_2 demand. If a community is already stressed from low flow, changes in 0_2 demand would more quickly cause an impact on it.

3.2.3 The Sandusky River at Bucyrus, Ohio

The Sandusky River is a major tributary to Lake Erie, its drainage area occupying 1,420 square miles of predominantly agricultural land in north-central Ohio (Figure 3-1). It flows east to west from its headwaters to Upper Sandusky, where it turns north and discharges into Sandusky Bay, the largest embayment on the southern shore of Lake Erie. The major urban areas in the basin include Fremont, Tiffin, Upper Sandusky, and Bucyrus.

Within the study area, the Sandusky River is predominantly unmodified and free-flowing. Minor channel modifications have occurred at RM 110.8 downstream from the Bucyrus WWTP. The majority of the Sandusky River is predominated by bottom substrates of cobble, gravel, and boulders.

3.2.3.1 Historical Information

A survey of the Sandusky in 1980 revealed significant impacts by CSOs, particularly downstream of Bucyrus. A study done in 1990 compared assessments after modifications were made to the Bucyrus WWTP (Ohio EPA 1991) with results from 1980. Trend assessment data showed that there was a general improvement in fecal coliform bacteria since 1979, though high counts still occurred downstream of CSO outfalls (Ohio EPA 1991). The WWTP was upgraded in 1988 and was successful in reducing, but not eliminating, CSO loadings. An improvement in the condition of the benthic macroinvertebrate assemblage downstream of the WWTP outfall (comparing 1990 samples to 1979 samples) reflects this plant upgrade. CSOs within Bucyrus were identified in 1979 as a significant source of organic degradation; moderate impacts to the invertebrate assemblage continued as recently as 1990.

Upstream of Bucyrus, a marginal decline in the condition of the fish assemblage was detected in 1990 as compared to that of 1979. As of 1990, the fish assemblage had shifted to more tolerant species, resulting in nonattainment of the state biocriteria for this river. Downstream of the WWTP, slight improvement in the fish assemblage was detected between 1979 and 1990. As with the macroinvertebrates, this increase in biological condition can be partially attributed to the WWTP upgrade in 1988. Additional improvement in the fish assemblage is expected since it is not unusual for recovery in fish populations to lag behind improvements in water chemistry and macroinvertebrate community structure (C.O. Yoder, personal communication).

3.2.3.2 Sampling Station Descriptions and Habitat Quality Assessments

Four sampling stations on the Sandusky River were selected for this study of Bucyrus CSOs (Table 3-1); habitat assessment rating scores, along with measurements of dissolved oxygen, temperature, and conductivity, are presented in Table 3-5.

Sandusky River upstream of Hwy. 30 bridge - Station SA1 (upstream reference). No habitat problems are evident at this station. The riparian zone is in an undisturbed condition, and there was little obvious sedimentation occurring. However, the riffle from which the samples were taken appeared as if it had been constructed, perhaps in an effort to enhance fish habitat with larger and deeper pools upstream and downstream. The riffle was composed of various-sized boulders, some very large. The upstream and downstream pools were too deep to wade in, and it appeared that the rocks had been removed from them for placement in the riffle. There was no indication of how long the riffle had been in place to allow for colonization. Nonetheless, habitat quality was unquestionably in the best condition of the Sandusky sampling stations, as it received an RBP habitat score of 153 (Table 3-5, Figure 3-4).

Sandusky River at Aumiller Park - SA2 (CSO impact). This station is located approximately 700 meters upstream of the Bucyrus WWTP at the downstream edge of Aumiller Park. Ohio EPA has indicated that the majority of CSO input is at this park. Here the river is experiencing severe physical disruptions apparently unrelated to CSOs. Heavy sedimentation is occurring due to the activity of heavy machinery approximately 150 meters upstream and bank failure at the station. Habitat quality ratings were in the marginal or poor category for embeddedness, all of the channel morphology parameters, and riparian vegetative buffer zone width. This station received a habitat quality rating score of 81.

Sandusky River downstream of Bucyrus, upstream of WWTP - SA3 (CSO impact). Station SA3 is located approximately 50 meters upstream of the Bucyrus WWTP and is downstream of most CSO outfalls. The station could not be located farther downstream of the CSOs due to the WWTP. According to Ohio EPA, there are numerous outfalls along the 700- to 750-meter stretch of the river between Aumiller Park and the WWTP. The river here rated suboptimal and marginal for embeddedness, width of riparian zone, bottom scouring, and deposition, and it had a low pool/riffle, run/bend ratio. (Throughout the entire reach of the river walked, approximately 750 meters, only three riffle areas were found.) One bank is part of an old landfill and is composed of soil completely interspersed

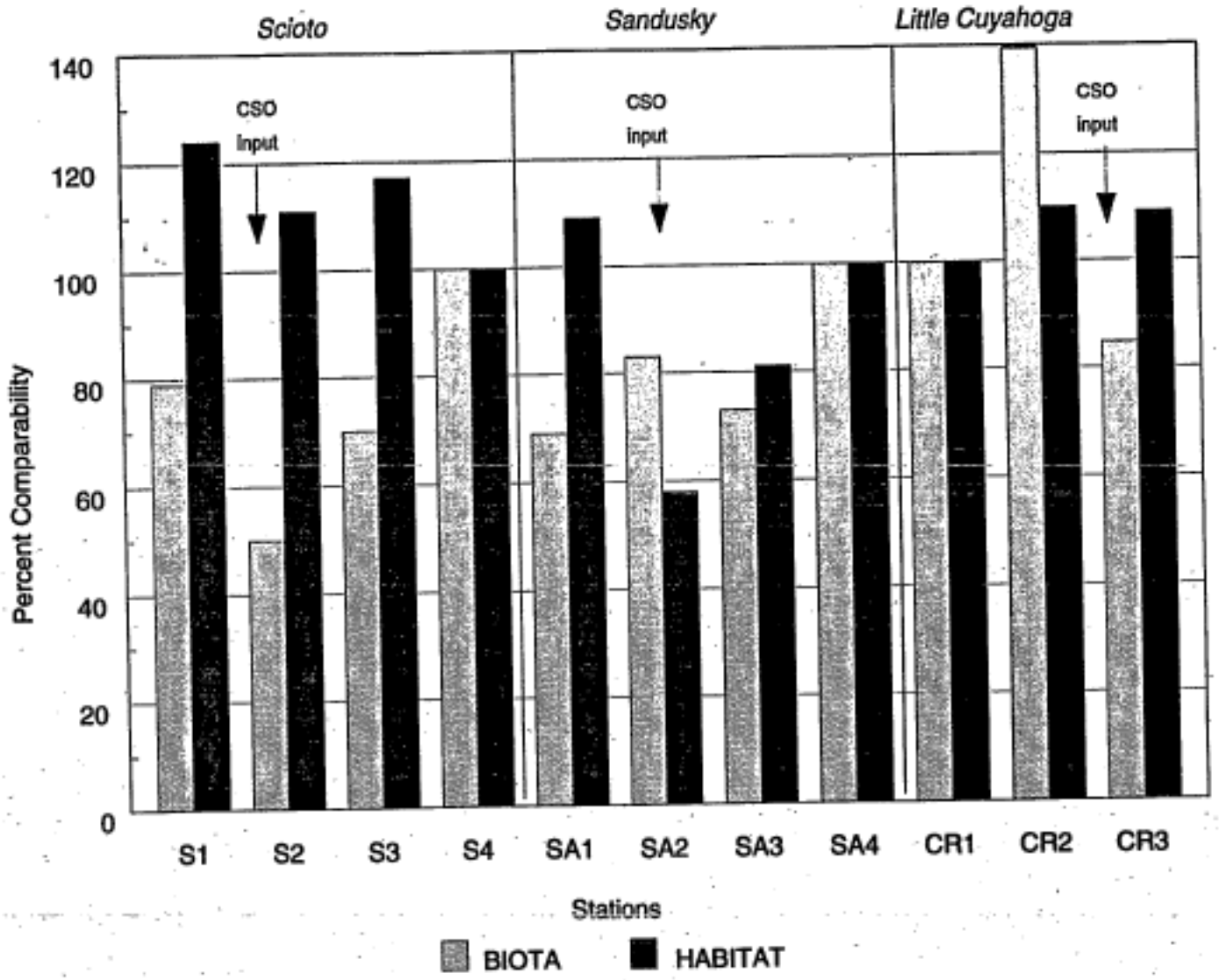

Figure 3-4. Percent comparability to reference sites for Ohio sampling stations.

Table 3-4 Calculated biological metrics for Scioto River, Sandusky River, and Little Cuyahoga River, Ohio; September 1992[a].

METRIC	S1	S2	S3	S4	SA1	SA2	SA3	SA4	CR1	CR2	CR3
1. Taxa Richness	18 (6)	19 (6)	22 (6)	20 (6)	18 (4)	22 (6)	21 (6)	21 (6)	14 (6)	16 (6)	11 (4)
2. HBI	5.1 (2)	4.7 (2)	5.3 (0)	4.9 (2)	4.9 (2)	5.1 (2)	5 (2)	4.4 (2)	5.2 (2)	6.3 (0)	5.9 (2)
3. Scr/(Scr + Fc) x 100	24 (6)	16 (4)	18 (4)	29 (6)	12 (0)	25 (2)	77 (6)	54 (4)	1.5 (0)	60 (6)	0 (0)
4. EPT/(EPT + Chir) x 100	83 (6)	42 (2)	54 (4)	87 (6)	97 (6)	92 (6)	80 (6)	98 (6)	98 (6)	43 (2)	28 (2)
5. % Contr. Dominant Taxon	28.4 (4)	28.2 (4)	29.9 (4)	17 (6)	57 (4)	37 (4)	27 (4)	23 (6)	78 (0)	18 (6)	35 (4)
6. EPT Index	8 (4)	6 (2)	12 (6)	12 (6)	7 (4)	10 (6)	8 (4)	11 (6)	2 (0)	3 (0)	2 (0)
7.CPOM: (Shredders/total) x 100	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Kick: (Shredders/total) x 100	0.003 (0)	0 (0)	0 (0)	0 (0)	0.2 (0)	0.5 (0)	1.3 (0)	0 (0)	0 (0)	0.03 (0)	0 (0)
8. (Hydropsychidae/total Trich) x 100	99 (0)	99 (0)	99 (0)	95 (0)	25 (6)	39 (4)	68 (2)	22 (6)	100 (0)	100 (0)	0 (0) [b]
9. Pinkham-Pearson	5.6 (4)	4.6 (4)	7.1 (6)	RR (6)	4.7 (4)	6.4 (6)	3.5 (4)	RR (6)	UR (6)	4.8 (6)	3.6 (4)
10. QSI-Taxa (%)	48 (2)	6.5 (0)	41.1 (2)	RR (6)	45.5 (2)	57 (4)	41.4 (2)	RR (6)	UR (6)	6.3 (0)	4.1 (0)
11. DIC - 5	3 (4)	1(0)	1 (0)	RR (6)	3 (4)	4 (6)	1 (2)	RR (6)	UR (6)	2 (2)	2 (2)
12. QSI-FFG (%)	82.5 (6)	73.7 (4)	83 (6)	RR (6)	53.8 (4)	71.1 (4)	79.3 (6)	RR (6)	UR (6)	14.3 (0)	22.9 (0)
Total bioassessment scores with paired metrics	44	28	38	56	40	50	44	60	38	30	18
Biology (with paired) % comparison to reference	79	50	69	----	67	83	73	----	----	95	47
Total bioassessment scores without paired metrics	----	----	----	----	----	----	----	----	14	22	12
Biology (without paired) % comparison to reference	----	----	----	----	----	----	----	----	----	157	86
Habitat scores	145	131	136	117	153	81	116	143	107	116	115
Habitat - % comparison to reference	124	112	116	---	107	57	81	----	----	108	107

For station and metric descriptions, see Table 3-2 and Section 2.3.2. Bioassessment scores (in parentheses) are derived by comparing metric values to scoring criteria (Table 3-1). (Paired metrics [9-12] used data from the regional reference (RR) station for calculations.)

[b] no Trichoptera collected.

Table 3-5 Habitat assessments and physicochemical measurements of the Sandusky River taken on 9 September 1992. For a description of the stations, see Table 3-2 and Section 3.2.3.2.

HABITAT PARAMETERS		SCORES			
		SANDUSKY RIVER SAMPLING STATIONS			
		SA1	SA2	SA3	SA4
Primary					
Substrate Instream Cover Flow Canopy (0-20)	Bottom Substrate/Instream Cover	17	10	10	18
	Embeddedness	16	5	8	17
	Flow or Velocity/Depth	19	16	16	18
	Canopy Cover (Shading)	18	16	18	10
Secondary					
Channel-Morphology (0-15)	Channel Alteration	12	3	13	13
	Bottom Scouring and Deposition	11	2	7	12
	Pool/Riffle, Run/Bend Ratio	14	4	7	13
	Lower Bank Channel Capacity	12	8	11	11
Tertiary					
Riparian and Bank Structure (0-10)	Bank Stability	9	5	8	9
	Bank Vegetative Stability (Grazing)	8	6	8	9
	Streamside Cover	8	5	8	8
	Riparian Vegetative Zone Width	9	1	2	5
TOTAL SCORE		153	81	116	143
Physicochemical Parameters	Dissolved Oxygen (mg/L) Temperature (C) Conductivity (μMhs)	8.6 19 750	7.7 20 700	6.9 16 650	9.5 21 450

with broken glass and rusted pieces of metal. However, enough soil is present to have been colonized by some woody and herbaceous vegetation. This station rated 116.

Honey Creek at Melmore (Hwy. 100) - SA4 (regional reference). This station is an Ohio EPA regional reference site. Even though the weather conditions were sunny and warm, the water level seemed to be up and, in fact, slightly rising while on-site. The water also appeared somewhat turbid. There might have been some rainfall upstream in the watershed causing these conditions. Aspects of the habitat that rated in the suboptimal or marginal ranges were related to channel capacity and the vegetated buffer zone. Water appeared to have intermittently escaped the channel on the side with a low bank. Also, the width of the riparian vegetative zone is reduced on one side by agricultural fields and on the other by mowing. In particular, the zone on the mowed side had a buffer zone of woody vegetation only approximately 3 to 6 meters wide. The habitat assessment rating score was 143.

The condition of the instream habitat and channel morphology at the Aumiller Park station (SA2) is indicative of considerable physical degradation. It might prove to be

limiting to the development of the benthic macroinvertebrate assemblage. Station SA3, just upstream of the WWTP and the downstream-most station on this river, has substantial riparian degradation and embeddedness with some evidence of scour, but it should provide habitat that will allow development of the benthic assemblage to a level comparable to that of the reference conditions. The best habitat encountered on the Sandusky was at the Fish Hatchery station (SA1), the Ohio EPA upstream reference station; the regional reference station habitat scored slightly less than SA1 but was comparable.

3.2.3.3 Biological Assessments

In the Sandusky River system, the regional reference (Figure 3-5; Honey Creek at Melmore, SA4) produced a total bioassessment score of 60. Station SA2, the upstream CSO-impact station at Aumiller Park, was most comparable to the regional reference at 83 percent comparability for biology (Figure 3-4), indicating nonimpairment; the slight reduction in biological condition was likely due to problems in habitat quality at this station. The downstream impact station, SA3, was slightly impaired, producing a habitat assessment score 73 percent comparable to the regional reference (Table 3-4). The bioassessment score least comparable to the regional reference was 67 percent at Station SA1, the upstream reference; this could be due to the habitat at SA1 being somewhat different with an apparently human-constructed riffle. Though this station was rated higher in habitat quality, the substrate composition might have had an effect on comparisons with the downstream stations, the substrate of which was primarily embedded cobble and gravel. Overall, the slight decrease in biological condition from SA2 to SA3 is attributed to additional CSOs and urban runoff, which further impaired the biological community in an area of increased habitat quality. These findings concur with the 1990 Ohio EPA survey of the Sandusky River (Ohio EPA 1991).

3.2.3.4 Comparison to Historical Assessments

The most recent Ohio EPA macroinvertebrate sampling on the Sandusky River, in 1990, categorized the macroinvertebrate assemblages at RMs 115.0 and 111.4 as "exceptional" and RM 111.1 as "marginally good" (Ohio EPA 1991) (Figure 3-6). The current study shows station SA1 (RM 115.0), the farthest upstream station, to be slightly impaired at 67 percent comparability to the regional reference station at Honey Creek (SA4) due to an apparent habitat alteration. Differences between the current study and that of Ohio EPA (Figure 3-6) might be attributed to gear differences (artificial substrate samplers by Ohio EPA and instream substrate in the current study). It is likely that sampling the bottom substrate directly with the kick net is demonstrating the difference in the habitat quality (substrate) at the two different stations, whereas use of artificial substrate samplers might have masked that difference by providing suitable "habitat" for colonization. Therefore, effects on the biological community observed when using artificial substrate might better reflect pure water quality differences.

Another factor could be the use of Honey Creek as a site-specific reference in the current study; Ohio EPA uses Honey Creek as one of the 133 reference streams that make up its reference condition for this class of stream. As stated earlier, the use of multiple reference sites (or reference conditions) are preferable to single reference sites. It should also be noted that the habitat disturbance at station SA1 noted in 1992 might have occurred after the 1990 sampling was conducted, but it was not possible to be certain. RBP samples were taken at RMs 111.5 and 111.1 (SA2 and SA3, respectively), bracketing the station found to be "exceptional" by Ohio EPA (1991). Comparability to the regional reference at SA2 was at 83 percent or "nonimpaired"; SA3 was 73 percent or "slightly impaired." Even with habitat problems at SA2 (RM 111.5), there was little indication of biological impairment compared to the regional reference.

At the downstream station (SA3, RM 111.1), there was slightly less habitat degradation in the form of scour and embeddedness but a further decrease in biological condition. Habitat problems at SA3 compared to SA2 were not as severe as those seen at SA2. Therefore, the slight biological impairment noted at SA3 can be attributed to influence from additional CSOs and urban runoff rather than habitat.

This assessment of slightly impaired biological condition at SA3 (RM 111.1) is similar to the Ohio EPA 1990 assessment (marginally good), which was also attributed to CSO inputs. These results seem to be compatible with those included in the most recent historical assessment reports (Ohio EPA 1991) (Figure 3-6). Additionally, SA2 might have experienced organic or fertilizer loading that caused a positive response of the benthic community (nonimpaired assessment). The initial phase of nutrient loading (organic enrichment) can mask the effects of habitat degradation by elevating the biological community (plants and animals). As organic enrichment increases, however, the bloom in the biological community begins to have adverse effects on the waterbody. For instance, algal blooms cause reduced light penetration below the water's surface and the bottom-dwelling plants die. As the abundant plant material decays, oxygen is used up rapidly, which causes further stress, and eventual more severe impairment of the biological community. Thus, while organic enrichment in the initial phase has a positive effect on the biology, it cannot be sustained over a longer periods of time.

3.2.4 The Little Cuyahoga River at Akron, Ohio

The Little Cuyahoga River flows through Akron in northeastern Ohio. The study area begins just downstream of Mogadore

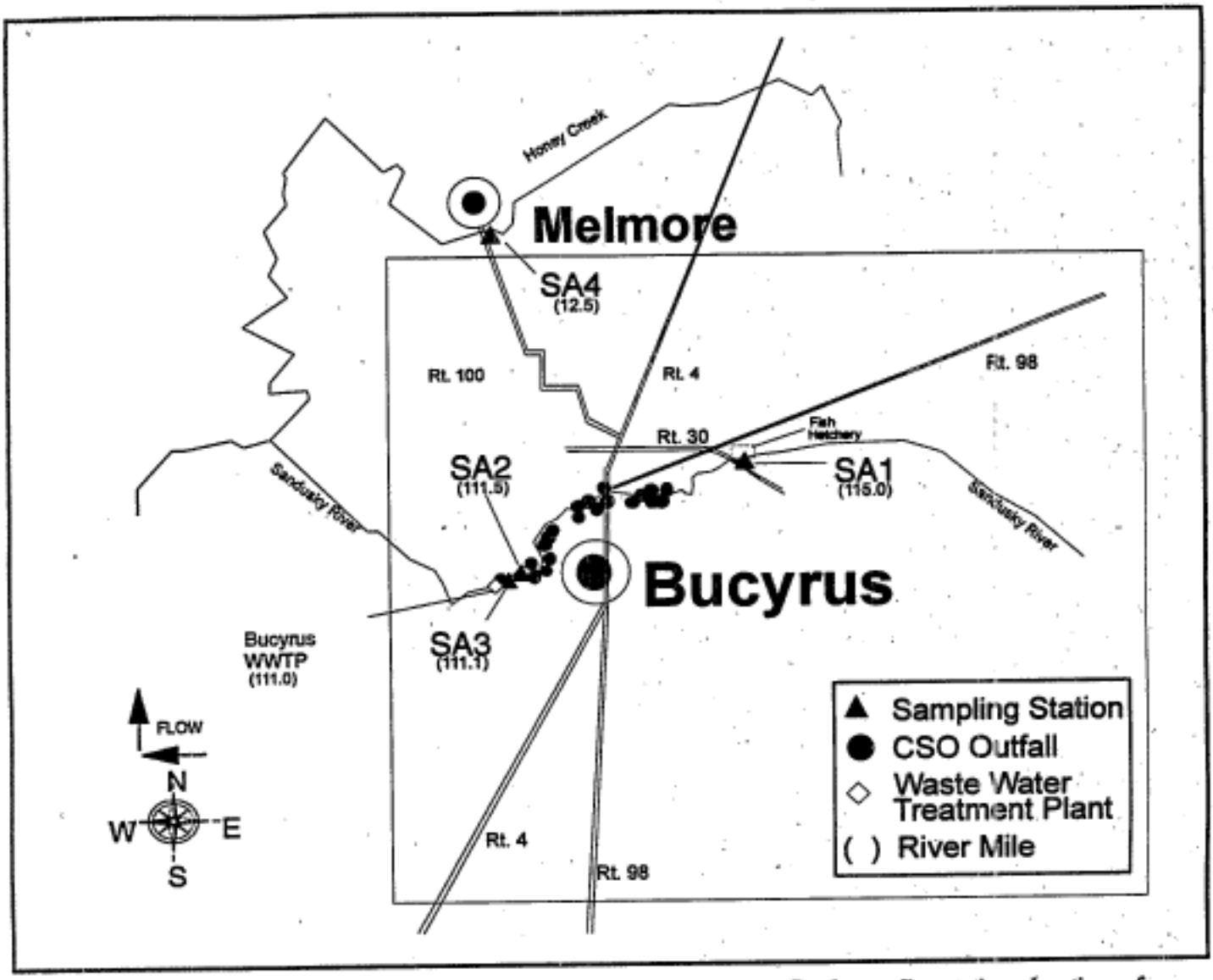

Figure 3-5. Cities of Bucyrus and Melmore, Ohio; Sandusky River and Honey Creek sampling stations, locations of historical data collections, CSO outfalls, WWTP, and river mile designations (approximate scale 1 inch = 6.0 miles).

Reservoir. Of the three stations sampled, the two downstream stations (CR2 and CR3) were expected to be receiving CSO input. It was later discovered that the outfalls upstream of the middle station had been eliminated in the past 5 years, leaving only the lower station to provide biological data expected to reflect response to pollutant input. This situation might allow the middle station to yield information on biological recovery following removal of CSO outfalls.

3.2.4.1 Historical Information

A benthic survey was conducted in 1986 on the Little Cuyahoga River. The ICI results indicated a combination of urban runoff and enrichment problems from lake and wetland drainage. These impacts resulted in a fair to poor ICI rating for most of the river between RMs 9.6 and 1.8.

The three sampling stations in the present study were also sampled in 1986: RMs 11.2 (RM 11.3 in present study), 7.1, and 0.3. However, of these three stations, only RM 0.3 was sampled in 1991 by Ohio EPA. In 1991, at RM 0.3 (upstream of the confluence with the Cuyahoga), the ICI reached the "fair" range and was essentially unchanged from 1986 (Ohio EPA 1994). In 1986, however, the condition of macroinvertebrate assemblage at RM 0.3 was lower than sites well upstream. The poor conditions were characterized by reductions in taxa richness, mayfly and caddisfly richness and abundance, and sharp increases in the percentage of tolerant invertebrate populations. These results were attributed to CSOs, urban runoff, and industrial point sources in Akron. Only a slight improvement (from poor to fair) was noted in 1986 at RM 0.3 when compared to the next upstream site at RM 3.8.

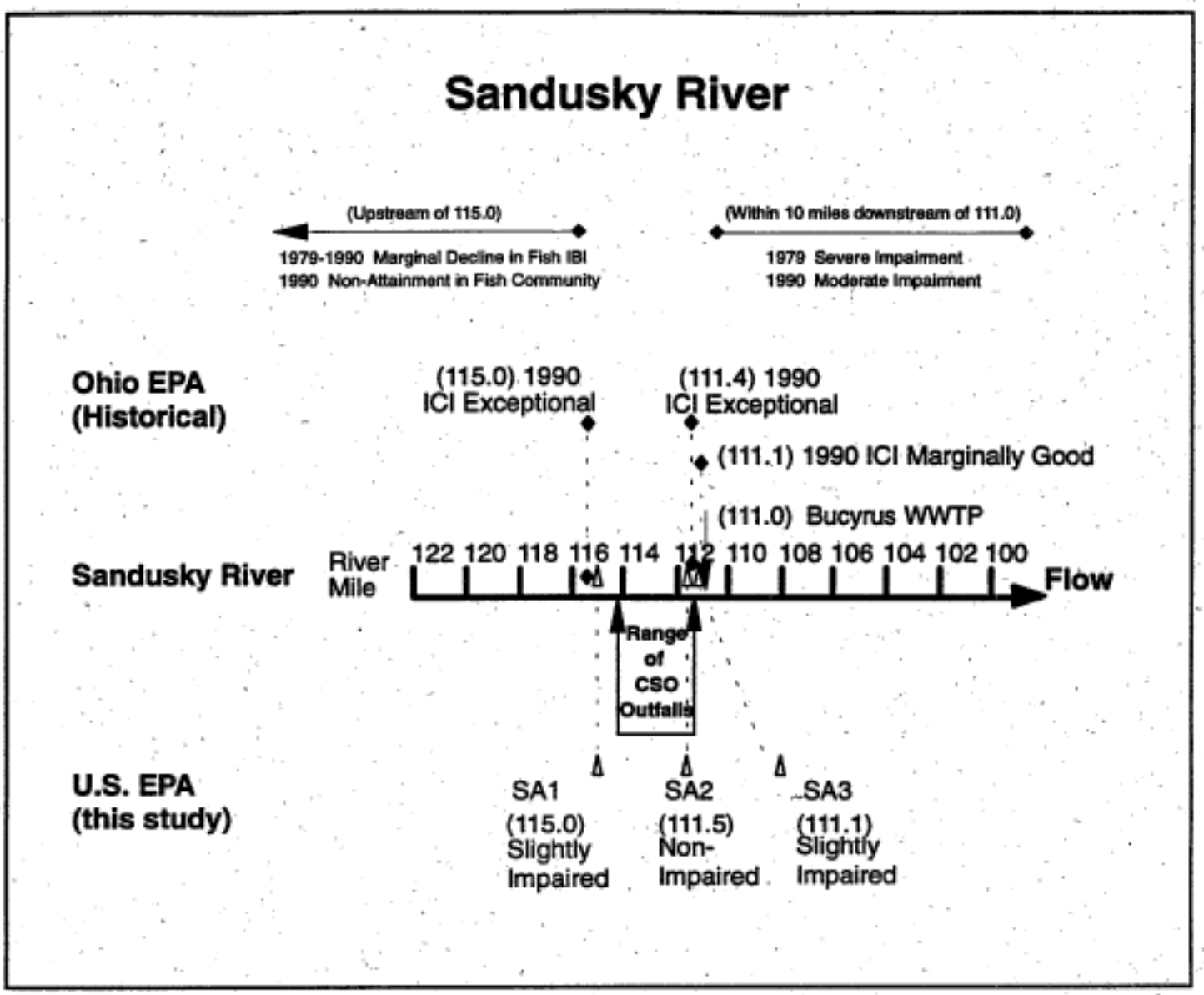

Figure 3-6. Linear comparison with Ohio EPA assessments on the Sandusky River.

3.2.4.2 Sampling Station Description and Habitat Quality Assessments

The three sampling stations on the Little Cuyahoga River selected for this study are presented in Table 3-1 and Figure 3-7. On visiting the regional reference stream used by Ohio EPA for the Little Cuyahoga (Breakneck Creek at Kent), it was found to be flooded out of its banks. Sampling could not be completed; therefore, the upstream reference station was used for comparison. Habitat assessment rating scores are provided in Table 3-6.

Little Cuyahoga River at Mogadore, Ohio - Station CR1 (upstream reference). This station is located approximately 2 miles downstream of releases from the dam of Mogadore Reservoir, well within the range within which physical channel alterations have been observed as a result of dam operations (Gordon et al. 1992; Rochester et al. 1984). However, this location was about 0.3 mile upstream from the station recommended by Ohio EPA as the reference station, which was inaccessible due to high flows. The station sampled contained no riffles; therefore, the samples were taken from runs. There was minimal variability of depths in the channel, a very strong flow, and substrate particles of mostly large cobble and small boulders with considerable embeddedness due to sand deposition. The sand was apparently coming from a sand and gravel pit upstream several hundred meters on one side of the stream channel. Station CR1 received marginal or poor scores on scouring/deposition; pool/riffle, run/bend ratio; and those parameters related to the riparian zone. This degradation is consistent with that expected downstream of dams

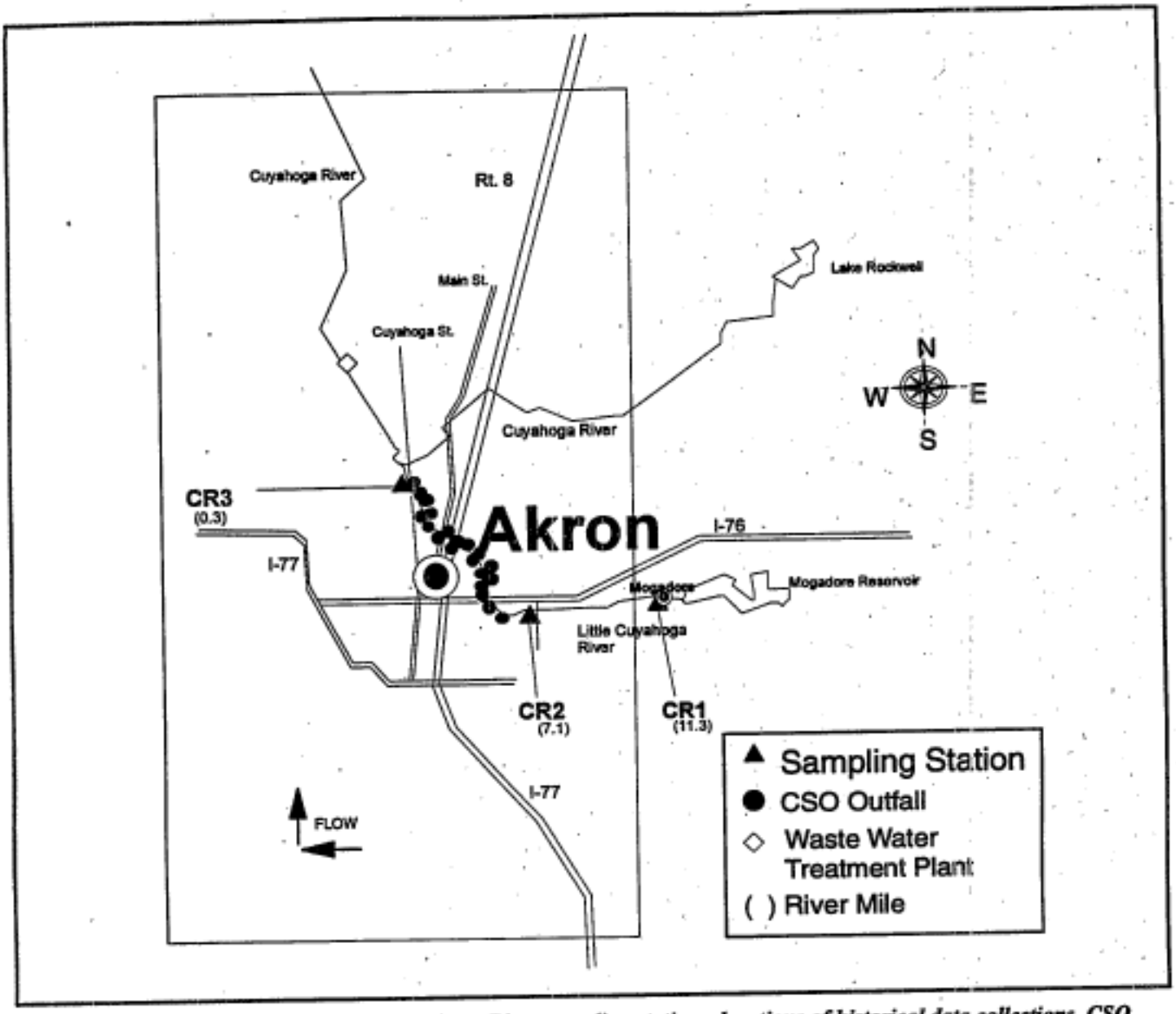

Figure 3-7. City of Akron, Ohio; Little Cuyahoga River sampling stations, locations of historical data collections, CSO outfalls, WWTP, and river mile designations (approximate scale 1 inch = 4.5 miles).

(Rochester et al. 1984). The overall habitat assessment score for CR1 was 107 (Table 3-6).

Little Cuyahoga River at Massillon Road bridge (State Rte. 241) - Station CR2 (upstream). Station CR2 is located in a heavily urbanized area of Akron (commercial/industrial/transportation). Components of habitat structure that were rated as suboptimal to poor included parameters related to a reduction in riparian vegetation and lack of variability in bottom contours, though some deep pools were present and there was diversity of substrate particle size. Riffles were at a minimum and samples were taken from runs. There was a stability of bank structure normally unexpected in such heavily urbanized areas. Habitat received an assessment score of 116, comparable to that of the reference station.

Little Cuyahoga River at the Police Firing Range off Cuyahoga Street - Station CR3 (CSO impact). The Little Cuyahoga River at Station CR3 experienced some sedimentation reflected in the rating scores for embeddedness, and scour and deposition. At this level the river is a straight channel without much variability in bottom contours, and substrate particle sizes were limited mostly to sand with some cobble and gravel. As at CR2, there were no true riffles; samples were taken from run areas. The station scored 115 on the assessment of habitat quality and was considered comparable to the reference station.

Table 3-6 Habitat assessments and physicochemical measurements of the Little Cuyahoga River taken on 24 September 1992. For a description of the stations, see Table 3-2 and Section 3.2.4.2.

HABITAT PARAMETERS		SCORE		
		LITTLE CUYAHOGA RIVER SAMPLING STATIONS		
		CR1	CR2	CR3
Primary				
Substrate Instream Cover Flow Canopy (0-20)	Bottom Substrate/Instream Cover	14	17	14
	Embeddedness	11	15	15
	Flow or Velocity/Depth	11	15	10
	Canopy Cover (Shading)	8	11	10
Secondary				
Channel-Morphology (0-15)	Channel Alteration	14	14	14
	Bottom Scouring and Deposition	7	11	8
	Pool/Riffle, Run/Bend Ratio	9	10	4
	Lower Bank Channel Capacity	11	7	13
Tertiary				
Riparian and Bank Structure (0-10)	Bank Stability	9	9	8
	Bank Vegetative Stability (Grazing)	5	2	6
	Streamside Cover	6	4	8
	Riparian Vegetative Zone Width	2	1	5
TOTAL SCORE		107	116	115
Physicochemical Parameters	Dissolved Oxygen (mg/L) Temperature (C) Conductivity (μMhs)	8 17 320	7.9 15 320	4 2 400

Overall, the Little Cuyahoga River, in the reaches of this study, has had considerable habitat degradation mostly from sedimentation and alteration of the riparian zone. However, the components of habitat quality that exhibited degradation were relatively consistent throughout the study area, and the resulting habitat scores were comparable at all three stations (Table 3-6). Thus, direct comparisons of the biological data among these stations should be possible and any observed differences can be interpreted to be the result of water quality problems.

3.2.4.3 Biological Assessments

Examination of metric values for the upstream reference station CR1 revealed a degraded biological condition. An increase in filterer collectors resulted in a low scraper to scraper + filterer ratio indicating potential organic pollution problems. The percent contribution of dominant taxon (78 percent Hydrosphychids), indicate poor community balance and account for the increase in filterers. Therefore, with no regional reference for comparison, this site (CR1) was not given a rating. The percent comparisons to reference (CR1) for stations CR2 and CR3 were made using metric totals without paired metrics; each assessment category was interpreted as one category less than those listed in Plafkin (1989) since the comparison was made using an impaired reference site.

The condition of the benthic community at station CR2 was considerably better than either the upstream or downstream

stations (CR1 and CR3, respectively). Although many taxa at this station were relatively tolerant, the taxa richness was the highest among the three stations and the percent contribution of dominant taxon was low.

A slight difference in condition of the benthic community was detected at the downstream station (CR3), which was 86 percent comparable to the upstream reference (Figure 3-4, Table 3-4). Because the habitat assessment was within the same range as that at CR1, the difference should be attributable to water quality. Specifically, there was a distinct depression in biological condition at CR3 (as exhibited by the metrics taxa richness, EPT-Chironomidae ratio, Pinkham-Pearson Community Similarity Index, DIC-5, and QSI-taxa), indicating the potential presence of toxicants from the CSO input. Abundance of invertebrates at both the middle and downstream stations was unexpectedly low (Appendix A): at CR3 a total of only 60 specimens were collected; at CR2, 133 specimens were in the total sample. At CR2 and CR3, a complete removal of organisms was required from the double-composite kick net samples in contrast to CR1, where a 300-organism subsample was taken. CR2 is considered to have a slightly impaired biology; CR3 is considered severely impaired.

3.2.4.4 Comparison to Historical Assessments

There are considerable habitat and discharge problems upstream of RM 11.0 along the Little Cuyahoga River (C. Yoder, pers. comm.). During low flow years, DO problems lead to decreased ICI values and thus lower bioassessment ratings. Ohio EPA found the upstream station of the Little Cuyahoga River (RM 11.2) to be in "fair" condition in assessments in 1986.

The upstream site assessment for the current study, (CR1 at RM 11.3) could not be rated due to evidence of biological impairment at the site and the lack of an accessible regional reference site to sample for baseline comparisons. Comparison to a degraded reference site falsely elevates the test site assessments. Thus, due to the degraded biological condition at CR1, the upstream reference site, assessments for CR2 and CR3 were lowered by one category.

Just above RM 11.0, a tributary from a natural and relatively undisturbed lake (Wingfoot Lake) enters the Little Cuyahoga River. This tributary entering above RM 11.0 is at least as large as the Little Cuyahoga upstream. This flush of clean water likely accounts for the Ohio EPA ratings of "good" and "very good" at the RM 11.0 station from 1986 to 1991 (Figure 3-8).

Just upstream of the CSO zone at RM 7.1 (Station CR2), the current RBP assessment found the stream to be "slightly-impaired", apparently somewhat improved over the 1986 ICI rating of "fair." This finding might reflect improvement following the removal of CSOs. While the biological condition along the entire reach of the Little Cuyahoga (RM 0.3 - RM 11.3, excluding RM 11.0), exhibits degradation, the station at RM 7.1 seems to have rebounded slightly since the removal of the upstream CSO outfall. At RM 0.3, the ICI (Ohio EPA 1986 and 1991) and RBP assessments were in agreement, with macroinvertebrate community evaluations of "fair" and "moderately impaired," respectively.

Results from the present study are consistent with those obtained by Ohio EPA in previous surveys (1986 and 1991). The macroinvertebrate assemblage at RM 0.3 (Station CR3) reflects an impaired condition that has been present since at least 1986 probably attributable to the combined influence of CSOs and industrial input. One station upstream of the CSO outfalls (CR1) was in similar condition to that indicated from a 1986 assessment; Station CR2 apparently improved following CSO removal.

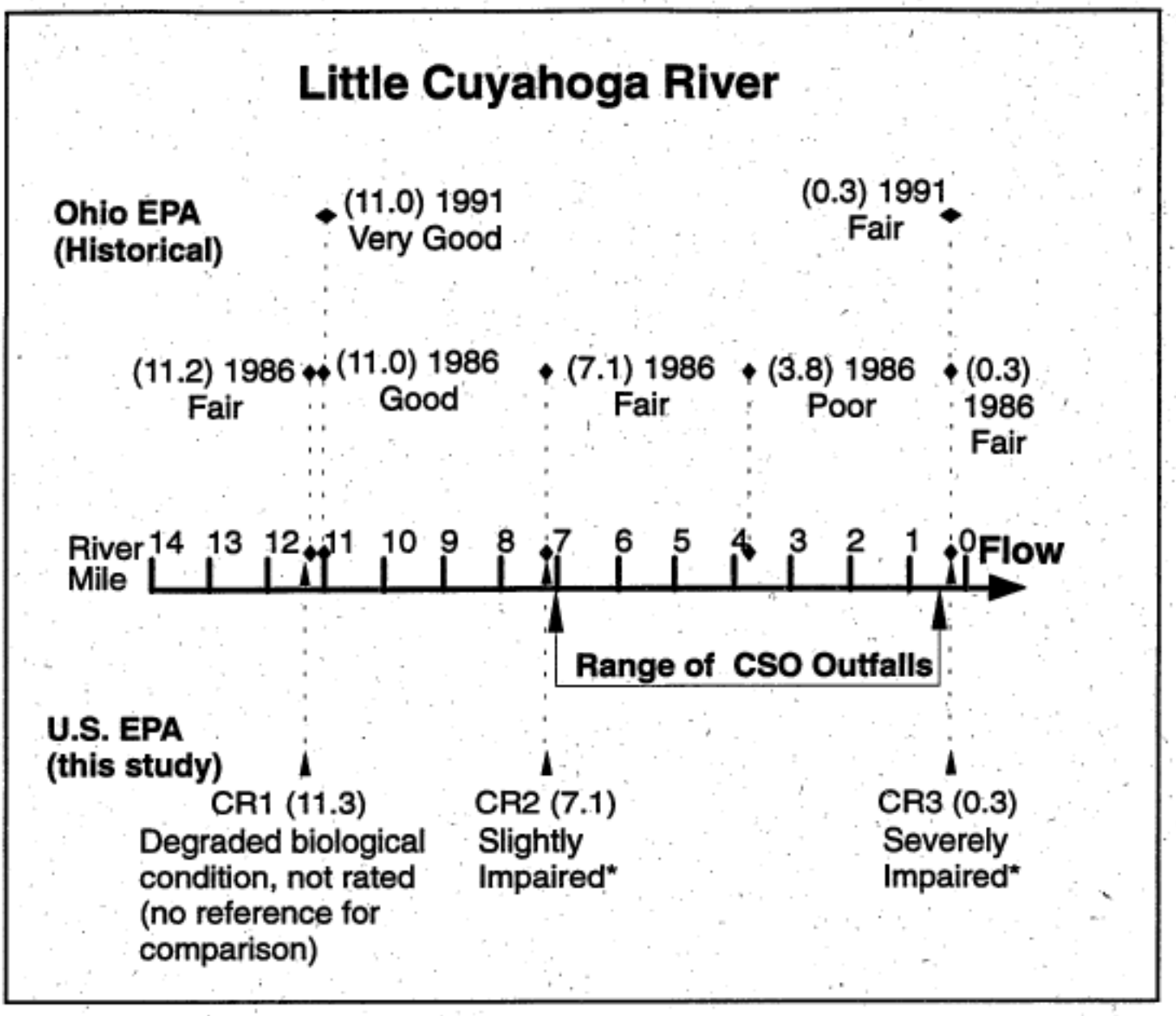

Figure 3-8. Linear comparison with Ohio EPA assessments on the Little Cuyahoga River.
**It should be noted that if an appropriate (non-impaired) reference condition was used as a baseline for comparison, all test sites for this study would likely receive lower biological assessment ratings.*